ask the AWRI

Winery nutrient management in a DAP-limited world

Food and agricultural sectors across the globe are currently experiencing reduced availability and/or increased cost of nitrogen-based fertilisers and additives, including urea and diammonium phosphate (DAP). The previous 'Ask the AWRI' column addressed the implications of urea limitations in the vineyard. In this column, AWRI Senior Oenologist, Geoff Cowey, and Research Manager – Biosciences, Dr Simon Schmidt, consider options for optimising nitrogen in the winery if DAP availability remains limited.

What happens to grapevines if nitrogen is limited?

Grapevines with insufficient nitrogen can show symptoms of nitrogen deficiency including reduced vigour, smaller leaves and shoots, reduced canopy density (and thus reduced photosynthetic area), delayed fruit ripening and reduction in yield. Delayed ripening affects grape berry sugar accumulation and the development of flavour compounds and their precursors. Nitrogen concentration in grape berries is also low when vines lack nitrogen.

How does this affect fruit and juice composition?

Grape nitrogen occurs in several forms: ammonium, amino acids, peptides and proteins. Fermentation yeast can only utilise ammonium and free amino acid nitrogen (FAN), collectively measured as yeast assimilable nitrogen (YAN). In healthy, freshly processed fruit, approximately one-third of the YAN will be ammonium and two-thirds will be from amino acids.

Optimal fermentation and wine quality are best supported by robust and balanced grape-derived nitrogen, with winery additions of DAP or other

nutrients ideally only used to fine-tune what is naturally present. Bell and Henschke (2005) reported a minimum recommended YAN level of >140 mg/L for grapes, musts and juices; however, actual demand depends on yeast strain and fermentation conditions. Scrimgeour *et al.* (2019) reported a median YAN value of 187 mg/L in Australian grape and juice samples from 2006-2019 (n=1,390). This means that around 50% of juices are likely to require nitrogen supplementation in the winery, with some needing more than just fine-tuning.

Up to 25% of grape nitrogen is present in the skin, with up to 65% present in the grape pulp, so for white winemaking, pressing off skins and removing grape solids will further reduce the available nitrogen in the juice. For red winemaking, in contrast, analysing only the juice may underestimate the available YAN. When fruit is compromised through heatwaves or disease pressures, or there are delays between harvest and the start of fermentation, the growth of native microorganisms can further reduce juice nitrogen concentrations.

What happens to a ferment if nitrogen is limited?

Low nitrogen concentration in juice (YAN <140 mg/L) can slow yeast reproduction and reduce the build-up of yeast cell biomass. Poor biomass formation decreases fermentation rates and yeast resilience in increasingly hostile conditions, resulting in sluggish or stuck fermentations. Low nitrogen also can increase the risk of hydrogen sulfide ('rotten egg') aromas developing and limit the formation of positive fermentation-derived flavours.

Should I use DAP, complex nutrients or both to adjust a low YAN?

If must nitrogen levels are low, inorganic nitrogen (DAP) and/or organic nitrogen (termed 'complex nutrients') can be used to supplement YAN. Complex nutrients are usually made up of dead yeast and parts derived from them, including components of cell walls (hulls), cell membranes, cell insides (yeast extract) or specific yeast fractions (mannoproteins). The nutritional components of complex nutrients usually include varying combinations of DAP, amino acids, peptides, vitamins, minerals and sterols/lipids. Some products may be supplemented with additional vitamins and some rehydration-specific nutrients may contain no ammonium salts. All these variations can make for difficult decisions when trying to amend low YAN.

From a fermentation performance perspective, DAP addition is a suitable treatment for correcting low initial YAN in juice. A 100 mg/L DAP addition yields a 20 mg/L YAN increase. It would be difficult to use complex nutrients whose nitrogen profile is comprised entirely of amino acids (i.e. contain no DAP) to make equivalent additions to juices with low YAN. At typically recommended dosage rates, the contribution of organic nutrients to YAN concentration is insufficient to make large adjustments. However, complex nutrient formulations are known to influence wine flavour development and can be used in combination with DAP, depending on the fermentation objective.

How can you make the most of your nitrogen in the winery?

The most important factor in making the most of nitrogen in the winery is to know the YAN of your juice or must. YAN analysis costs around $30 but is typically only performed regularly by medium-to-large sized wineries (Nordestgaard 2019). Other wineries typically make standard DAP additions to yeast cultures and musts, relying on (what has been historically) the relatively low cost of DAP. As not all vineyards are nitrogen-poor, measuring YAN in grapes, or juice in tank, will allow informed decisions on how to best use available DAP. In addition, yeasts can vary in their nitrogen demand. Understanding juice YAN status can help inform yeast strain choice and nitrogen management strategy.

YAN concentrations should also be considered in the context of sugar concentrations. Several studies have shown that complete fermentation of high-sugar musts requires higher nitrogen concentrations than musts from less mature fruit. Therefore, the minimum nitrogen rule of thumb (~150 mg/L) should increase with increasing sugar concentration.

Additions should be timed for optimal effect. Grape-derived ammonium will typically deplete within 48 hours of inoculation. Ammonium depletion will coincide with the time when *S. cerevisiae* is most rapidly growing. This period is the ideal time for DAP additions (at 10-25% of fermentation duration). Yeast nitrogen demand is high because of the rapid growth; therefore, the impact from ammonium addition is greater than if made later in the fermentation. It is worth bearing in mind that if grape-derived nitrogen concentrations are already high, then DAP additions at the very beginning of fermentation can lead to an overly rapid ferment rate. Small nitrogen additions later in fermentation can help stimulate fermentative activity (i.e. CO_2 production) but will not help yeast to grow. At these later stages, amino acid-based nutrient additions may be more useful than DAP to help sustain robust and vigorous yeast populations. Complex nutrients can also help support stylistic wine attributes.

Planning for the vintage early, having a nutrient strategy for planned ferments, measuring YAN, supplementing ferments only when required, and ordering nutrients early are all steps that can help alleviate the current supply constraints.

References

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